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Ben Taub General Hospital is experiencing numerous emergency center ambulance diversions. The diversions are a symptom of lack of bed availability or slow patient throughput. Patient throughput is a function of appropriateness of admissions, accelerated post-acute transfers, and expedited care. Further, enhanced discharge processes such as earlier physician rounds can reduce diversions but has little effect on throughput when measured in days. The purpose of this study is to determine if the hospital can alleviate bed capacity constraints. Descriptive and inferential analyses were conducted for each group of variables affecting patient throughput. The average length of stay of 5.87 days was used to calculate the potential for increased throughput. Inappropriate admissions, specifically 388 observation patients, block 56 other patients from beds per year. Thirty-two medically stable long stay patients impede 704 patients from inpatient care per year. Finally, expediting the care itself holds the promises of 10,761 additional patients per year.

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Increasing Throughput

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Abstract

Ben Taub General Hospital is experiencing numerous emergency center ambulance diversions. The diversions are a symptom of lack of bed availability or slow patient throughput. Patient throughput is a function of appropriateness of admissions, accelerated post-acute transfers, and expedited care. Further, enhanced discharge processes such as earlier physician rounds can reduce diversions but has little effect on throughput when measured in days. The purpose of this study is to determine if the hospital can alleviate bed capacity constraints. Descriptive and inferential analyses were conducted for each group of variables affecting patient throughput. The average length of stay of 5.87 days was used to calculate the potential for increased throughput. Inappropriate admissions, specifically 388 observation patients, block 56 other patients from beds per year. Thirty-two medically stable long stay patients impede 704 patients from inpatient care per year. Finally, expediting the care itself holds the promises of 10,761 additional patients per year.

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Introduction

Background

According to the 2002 American Community Survey Profile, 3.5 million or 16% of the 21.2 million Texans live in Harris County (U.S. Census Bureau, 2002). Although 16% of Texans live in poverty, Harris County fairs a bit better with a 15% poverty rate, but is worse than the 12% national average (U.S. Census Bureau, 2002). When it comes to health insurance Texas has the highest medically uninsured population in the U.S. with 24.7% compared to the national average of 15.2% (U.S. Census Bureau, 2003). According to the Harris County Hospital District, approximately 1.1 million Houston residents do not have health insurance (Schlegel, 2003). This estimate is astonishing because Harris County, Texas has 3.5 million residents, meaning over 31% lack health insurance.

Fortunately, the Harris County Hospital District (HCHD), part of the Texas Medical Center, provides medical services to all Harris County residents regardless of their ability to pay (HCHD, n.d.a.). The District was created in 1965 in response to criticism of patient neglect exposed in De Hartog's book *The Hospital*. Today, the District is the nation's fourth largest metropolitan health system and has a $670.6 million operating budget, over 49,000 admissions to 923 beds, 180,000 emergency visits, and more than 1,000,000 clinic visits annually (HCHD, 2003).

Unfortunately, in one of the nation's largest cities, only two Level 1 Trauma Centers are currently in operation, one of which is in the HCHD at Ben Taub General Hospital. In addition to its world-renowned trauma program, Ben Taub is also an academic teaching hospital with more than 40 medical specialties, 647 licensed-beds, and 588 staffed-beds (HCHD, n.d.b.). Last year, Ben Taub had over 24,000 admissions, of which 80% came from more than 100,000 emergency visits (HCHD, 2003). With an average 5.87-day adult length of stay, the inpatient beds are usually occupied or pushing the edge of full capacity. Table 1 displays the annual inpatient activity summary for fiscal year March 2002 to February 2003.

Conditions that prompted the study

The Ben Taub General Hospital is experiencing numerous Emergency Center (EC) ambulance diversions due to EC saturation and lack of inpatient beds. From January 2003 through August 2003, the EC went on diversion status 299 times for a total of over 3,000 hours. This is especially troubling because over 80% of the Houston Fire Department life-threatening ambulance runs roll up to Ben Taub (HCHD, n.d.a.).

Statement of the Problem or Research Question

Diversions are a symptom of lack of bed availability and slow patient throughput. Unless Ben Taub General Hospital can improve patient throughput, diversions will continue to hamper the delivery of patient care for Harris County residents.

Table 1. *Annual Inpatient Summary: March 2002 - February 2003*

Measure	Performance
Adult and Pediatrics	
Beds (Staffed)	507
Admissions	24,605
Discharges	24,750
Average Length of Stay (days)	5.87
Percent Occupancy	78.36
Operating Procedures	10,855
Newborns	
Basinets	81
Admissions	12,022
Discharges	12,032
Average Length of Stay (days)	3.86
Percent Occupancy	56.38

Literature Review

An undersupply or lack of inpatient bed capacity is not a problem isolated to Ben Taub. As a result of prospective reimbursement, over the last several years, hospitals have been downsizing and shifting from an inpatient to an outpatient focus. Unfortunately, the aging of the population and increasing number of uninsured is beginning to put pressure on hospital capacity. According to the National Center for Health Statistics (2002), emergency department visits increased 14% from 1997 to 2000. Knight (2003) reports almost 20% increase in visits from 1992 to 2001 with a 15% corresponding decrease in the number of hospitals with emergency rooms. The answer seems simple: build more capacity. However, this approach takes time, staff, and money. Therefore, the short-term alternative is to maximize capacity by expediting patient throughput (The Advisory Board, 2003).

A study conducted at Ben Taub highlights its inpatient bed shortage (McGlory et al., 2002). The focus of the study was displaced specialty unit patients and the effect on nursing staff. Due to a lack of appropriate critical care beds, patients were admitted to a variety of units usually not trained or equipped to handle the special needs of the patient. In essence, these patients were *on-hold* until subsequent transfers were arranged. The length of the delay averaged 54.4 hours, with a maximum delay of up to 72 hours. The results of their study were used to train nursing staff, but the issue of displaced admissions was still unresolved. Proudlove, Gordon, and Boaden (2003) describe displaced patients as outliers placed inappropriately on wards not designated for the type of care the patient requires and say that subsequent transfers are disruptive and add at least one day to length of stay.

Czaplinski and Diers (1998) examined the displaced patient issue from a different perspective. This study examined the length of stay and mortality rates for 16 different diagnosis related groups. Nine of the 16 groups had shorter lengths of stay if they were cared for on specialty units. Four of the 16 groups had lower mortality rates. Clearly, patients requiring critical or specialized care should be cared for on the appropriate specialized unit and not placed in the first available bed or held in the emergency center. But, if the hospital has a shortage of appropriate beds the system backs up, the emergency center fills up, surgeries get postponed, patients begin to back up waiting for beds, and eventually the hospital goes on diversion turning away ambulances.

A 5-year efficiency study of an emergency department treating 41,000 patients per year showed that bed availability was a significant factor in increased wait times and therefore in overcrowding and diversions as well (Kyriacou, Ricketts, Dyne, McCollough, & Talan, 1999). In fact, if a bed was available, the median wait time decreased from 220 minutes to only 95 minutes. Another study confirmed inpatient bed availability as a significant factor influencing patient flow, efficiency, and overcrowding in the emergency department (Miro et al., 2002). Both studies examined the effects of time, process improvements and reorganizations.

The Joint Commission on Accreditation of Healthcare Organizations suggests the possibility of a simpler solution to the emergency department overcrowding than reorganization (ED Overcrowding, 2003). To minimize overcrowding and diversions, patients can be pushed to the units or the units' hallways. Why hold patients in the busiest department (emergency department) in the whole hospital, when they can be cared for on the appropriate inpatient units? The article referred to this strategy as a "Full Capacity Protocol" (p. 6). This protocol is elaborated on in a separate article, which asserts patient care is improved and length of stay is reduced due to the protocol (Anonymous, 2003a). In the article, the Vice Chairman of the Department of Emergency Medicine, School of Medicine, State University of New York at Stony Brook, Dr. Peter Viccello reported a reduction in length of stay from 6.2 days to 5.4 days simply by moving patients upstairs and postulated the following:

> There are times that departments are overloaded, and there aren't any beds. But often times, when patients are moved upstairs to the hallway, a bed magically becomes available. This behavior is rampant throughout the hospital industry. The bed may become available at 1:00[PM], but it doesn't get reported until the change of shift. Trying to get patients discharged early and nurses to report an available bed is fighting a losing battle. There is no incentive for them to rush or get patients upstairs. Once the problem is

put in their lap, then they act to solve that problem (p. 44).

Val Gokenbach called this phenomenon an "out-of-sight, out-of-mind" philosophy (Anonymous, 2000, p. 140). To combat this, William Beaumount Hospital in Royal Oak, Michigan uses a similar full capacity protocol called Code Purple. At first the hospital tried increasing staffing levels and physician coverage. However, the bottleneck was lack of space and available beds, not staffing. Code Purple is considered a mini-disaster and the whole hospital responds by creating short-term hallway spots to relieve pressure in the emergency department. This team approach makes the overcrowding problem everyone's predicament and responsibility to resolve. Proudlove, Gordon, and Boaden (2003) allude to this as a push system rather than a pull system, where the patients are pushed along by the congestion behind them rather than on their acuity needs. Pull systems are more proactive and plan the care as well as anticipate the discharge, therefore are preferred over push systems.

Greater efficiency in the emergency department to alleviate overcrowding and wait time is possible using a variety of different methods. These methods include an examination and overhaul of hospital wide-processes (Nursing Executive Watch, 2003a), implementation of fast track emergency care centers (The Daily Brief, 2001) and appropriate use of bar coding technology

(Anonymous, 2002). One facility has completely eliminated its emergency waiting area and now shuttles patients directly to private rooms (Knight, 2003). Although minor process improvements to complete reengineering in the emergency department can increase department efficiency, they do nothing to remove the bottleneck caused by lack of inpatient beds.

Perhaps the best way to increase patient flow and efficiency is by conducting time studies (Anonymous, 1999). When conducting time studies, mapping the flow and collecting data for time of day as well as day of the week are important (Backer, 2002; Karpiel, 2000). However, Chan, Reily and Salluzzo (1997) found that day of the week did not have a statistically significant effect on patient throughput; rather the number of inpatient admissions had the highest correlation. Another study, contrary to popular belief, found that taking the time to concurrently teach medical students does not significantly change patient throughput in the emergency department (Chan & Kass, 1999). Again, improving subsections of the entire system is possible, but throughput depends on and is hampered by the constraining factor: available beds.

Good bed management can remove some of the capacity constraint caused by lack of adequate beds (Proudlove, Gordon, & Boaden, 2003). Proudlove et al. assert that the entire patient care episode should be considered one system from the admission to discharge and that effective management of the system requires integration. Further, most system delays arise from general problems at the discharge phase; therefore beds are the main capacity constraint. Studying the cyclical supply and demand for beds reveal that both emergency and elective admissions peak early in the week; conversely, discharges usually peak late in the week. Proudlove et al. go on to state, "There are no statistically significant correlations between emergency and elective admissions. This confirms the lack of coordination between scheduling elective load with emergency demand" (p. 151).

Some argue that if hospitals increase patient throughput or decrease length of stay it puts the patient in jeopardy. If patient care were exclusively focused on pushing patients through the system, it could jeopardize quality care. However, studies on patient volume and outcome show no adverse effects on quality (London & Battistella, 2003; Margullies et al., 2001). In fact, one study showed improvement in outcomes such as patient mortality and reduced lengths of stay with increase volume (Nathens et al., 2001). This lends credence to the specialized unit philosophy where doctors and nurses can become very proficient in performing certain specialized types of care (e.g., cardiac care units).

However, even on specialized units, doctors do not practice medicine the same way. Variations in the delivery of patient care exists, therefore, improvement can be made (Eddy, 1990;

Wennberg & Gittelsohn, 1973). Clinical pathways and case management can be very effective ways to eliminate variance, standardize patient care, and increase volume (Bennett, Fosbinder, & Williams, 1997; Bristow & Herrick, 2002; Johnstone & Zolese, 1999; Kwan & Sandercock, 2003; Renholm, Leino-Kilpi, & Suominen, 2002).

Purpose

The purpose of this study is to determine if the hospital can alleviate bed capacity constraints through better use of resources and process improvements. The analytic approaches contained in the Advisory Board's *Maximizing Hospital Capacity* (2002) and *Throughput Gap Analysis* (2002) form the basis of the investigative framework for this study. The analysis can be broken down into five major categories: Appropriate Admissions, Accelerated Post-Acute Transfers, Streamlined Bed Placement, Earlier Patient Discharges, and Expedited Care Delivery. Figure 1 illustrates this framework with a conceptual model. A tube or pseudo-pipeline is meant to represent patient throughput through the continuum of care. Inpatient care begins with an admission. The pipeline width is finite in size and therefore is capacity constrained. If inappropriate admissions are occurring, the capacity is reduced. The patient care itself can be broken down into two phases: acute care phase and medically stable phase. The acute care phase can potentially be reduced or expedited with standards of practice and elimination of variance. The post acute phase or medically stable phase is superfluous and is characterized by a stable patient waiting for discharge or transfer. Finally, the discharge phase removes the patient from the pipeline and ends the episode of care.

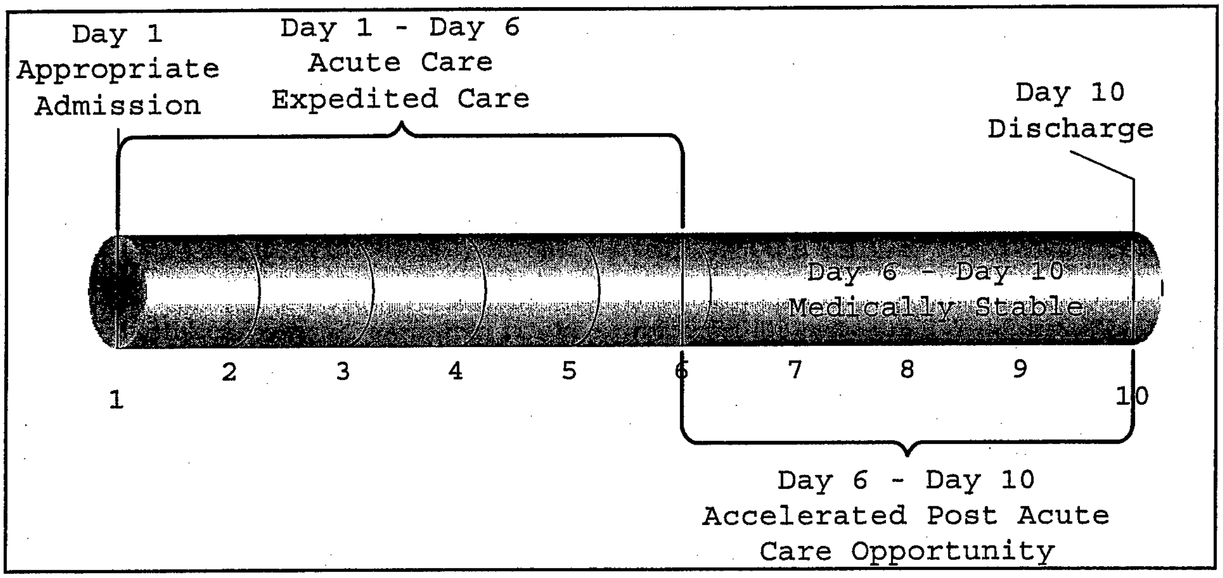

Figure 1. Ten-day patient stay illustration. Ensuring only appropriate admissions, expediting care where possible, accelerating post acute transfers, and streamlining discharge process can increase patient throughput.

The general model for this study is: Patient throughput is a function of appropriateness of admissions, patient discharges timing, length of care, and post-acute transfer timing. The following analyses will be conducted to determine if Ben Taub can increase patient throughput:

a. Appropriateness of Admissions. Decreasing inappropriate admissions, such as admitting observation patients for longer than 23 hours, will increase bed availability. An observation patient length of stay analysis will quantify the number of outpatients in inpatient beds and predict increased throughput with the implementation of a dedicated observation unit.

b. Earlier Patient Discharges. Changing physician rounding practices will speed patient discharges and increase bed availability. Earlier patient discharge will reduce bed placement process delays and offer the Emergency Center (EC) a release valve other than diversions; therefore, wait time and number of diversions in the EC can be reduced. A descriptive analysis comparing physician rounding times to admission and discharge times will demonstrate the potential for earlier patient discharges.

c. Length of Care. Physician practice patterns vary. Due to the Graduate Medical Education conducted at Ben Taub, physician-resident teams provide care on specific wards. Comparing lengths of stay for Diagnostic Related Groups (DRG) that are performed on several wards by different teams will substantiate the potential to reduce length of care.

d. Accelerated Post-Acute Transfers. If Social Workers and Case Managers could reduce long stays, patient throughput would increase. An analysis of long stay patients will reveal the possibility of faster post acute transfers.

Methods and Procedures

Sample and Data

Data were gathered from Harris County Hospital District historical files including the monthly and annual reports, emergency center diversion reports, and long stay reports. In addition, examination of patient medical records and inpatient unit staff interviews supplied further details. Finally, ad-hoc queries from the corporate databases rounded out the compilation of data. Operationalization of the variables contained in this dataset is discussed in a separate section below.

Hospital operational performance data were obtained from the Harris County Hospital District Monthly and Annual Statistics Reports. Fiscal Administration at the district prepares the reports. Available electronic data ranged from March 2001 to July 2003 covering 29 months. The district's fiscal year begins the first day of March, thus the data consist of the 2 previous fiscal years and 5 months of the current fiscal year. Additionally, the number of emergency diversions per month and the length of the diversions per month were concatenated with the operational performance data.

The Emergency Center collects and reports diversion information to Executive Administration on a monthly basis. Diversion data were gathered for this study to correspond to the same time frame of the inpatient summaries as discussed above: March 2001 to July 2003 (n = 299). This approach facilitated the data analysis and helped to examine the relationship between hospital operational performance and diversions.

In March of 2003, the Social Services department reorganized and began tracking long stay patients in more detail. Long stay patients were defined as having a length of stay greater than 6 days. A register was developed with all the long stay patients who became medically stable but were unable to be discharged. Medical stability was determined by the physician and recorded in the progress notes of the medical record. This information was recorded at a patient level. Further, the data were collected only for those patients who were discharged and therefore did not duplicate observations. Just over six months of data were available on patients with discharges from March 25, 2003 until the end of September 2003 for a sample size of 32 patients.

Physician rounding times and the number of beds per unit were acquired by interviews with unit staff. Typically, the unit Nurse Manager provided all the required information. However, Assistant Nurse Managers were also interviewed. Information was obtained for all inpatient units.

Ad hoc queries from the district database concluded the data assemblage. Patient level records were acquired from September 2002 to August 2003. Emergency and inpatient data were obtained from one query (n = 119,271) and observation patient data from another query (n = 388).

Validity and reliability

Data gathered from corporate reports and databases are part of the historical record and therefore as accurate and reliable as possible. Periodically, data gathering methods change and can add to or discontinue available information. However, validity and reliability of data are not related to its availability. Fortunately, data gathered for this study did not have changes in definitions or collection methods, therefore the reliability is high. Executive Administration and District leaders use these data to make critical decisions. For this reason, the accuracy or validity of the data is also high.

Ethical considerations

Although patient level information was used, no details are reported and privacy is protected. All specifically identifiable references to patient information have been removed.

Operational Definitions of Variables

Monthly inpatient summary data from the District's historical files consisted of hospital operational performance data. Variables of interest included the number of admissions, emergency center visits, clinic visits, operating room procedures, patient days, discharge days, and discharges. Emergency center visits were categorized into surgical, medical, or psychiatric visits. Average daily census, average length of stay, and percent occupancy were also pulled from the historical files and analyzed. Lastly, the number of diversions and the length of the diversions accumulated by month were gathered from the Emergency Center Diversion Reports and added to the historical operational performance data using the corresponding month as the index. The number and length of the diversions are the only monthly variables calculated and not pulled directly from a database.

Diversions occurred when Ben Taub Emergency Center staff members officially requested that Harris County ambulance traffic be rerouted to other facilities due to potentially unsafe conditions resulting from patient volume saturation or lack of resources. Diversion data from the Emergency Center Diversion Reports included the date and time the diversion was declared and discontinued. The data also incorporated the hospital service requiring the diversion and specific comments detailing the reason for the diversion. Duration of the diversion was calculated by subtracting the start time and date of the diversion from the end time and date. Then, a monthly total was obtained for use with the monthly inpatient data. In addition, the date each diversion began was used to code the day of the week of the occurrence.

A patient is considered to be long stay patient if the length of stay is more than 6 days and the patient becomes medically stable. Data obtained from the physical patient records for long stay patients included the admission and discharge dates. Further, the date the patient became medically stable was obtained. The total length of stay was calculated simply by subtracting the admission date from the discharge date. Similarly, the stable length of stay was calculated by subtracting the stability date from the discharge date.

Inpatient and emergency center patient data pulled from the corporate databases included, by patient, the admission date and time and the discharge date and time. Lengths of stay in time format and in decimal format were calculated. Two calculated lengths of stay were negative due to apparent data coding errors and therefore were deleted from the analysis. Cross tabulation revealed an emergency case erroneously assigned a DRG code. Although this may have been a legitimate case, in order to avoid mis-categorization as emergency or inpatient, the case was deleted. The data sanitizing left the sample size as 119,268 patients. A binary variable was coded one for any length of stay six days and over, zero otherwise. Demographic data included sex, race, and date of birth. The age at discharge was calculated using the discharge date and the date of birth. Hospital data included the admitting doctor's index number, the DRG, the unit location designation such as *3A*, *5B*, or *6E*, and an inpatient service code such as *PEDS*, *SURG*, or *MEDS*. Binary unit location variables were coded for each unit. Finally, the hour of arrival at the emergency center, admission, and discharge were coded for each record.

Observation patients are patients who require monitoring for minor and some emergent problems and who are expected to be discharged in 23 hours or less. Observation patient data were pulled form corporate databases in a separate query from the emergency and inpatient data. However, the initial data were identical to inpatient and emergency data. Length of stay was calculated in the same manner as described above. A binary variable was coded to indicate lengths of stay above 23 hours. Finally, a variable was calculated with the number of hours above 23 hours in order to aggregate the total number of extra observation time.

Investigative Methods

The impetus of this study was emergency center ambulance diversions. Emergency Center (EC) saturation can occur due to high demand and lack of available resources. Demand is largely outside the control of the hospital. Emergency center staffing did not appear to be an issue, therefore the focus shifted to resources, specifically downstream inpatient beds. In order to better understand what was happening, the number of diversions and the length of the diversions were scrutinized by the day of occurrence. First, simple chi square (χ^2) goodness of fit tests were used to determine if the number of or duration of diversions varied by the day of the week. Once a pattern became evident and a basic understanding of the chain of events leading to diversion was discerned, a hypothesis emerged.

The research hypothesis was that Ben Taub could reduce emergency room diversions by increasing patient throughput. Patient throughput is a function of appropriateness of admissions, patient discharges timing, length of care, and post-acute transfer timing. Therefore, in depth statistical analyses were performed focusing on inappropriate admissions in the form of observation patients; faster discharge or transfer by targeting long stays; inpatient discharges timing, specifically evening planning rounds and earlier morning discharges which should reduce the congestion in the emergency room; and finally, on reducing the length of stay by DRG.

Inappropriate admissions were investigated by looking at observation patient length of stay and location of stay in order to determine the potential for improved patient throughput. Frequency distributions revealed that 3 of the 388 records were missing demographic information. However, the length of stay information was available and used to develop descriptive statistics. Length of stay in hours was examined from two points of view: the overall length of stay and the amount of stay above the normal 23-hour observation period. Cross tabulations and goodness of fit tests were used to explore the difference in occurrence by month and by location. Finally, the potential increase in patient throughput was calculated by dividing the number of days observation patients occupied an inpatient bed by the hospital's current average length of stay: 5.87 days.

In regards to the potential for faster post-acute transfers, medical records for long stay patients were examined to determine how much of the length of stay was unwarranted. The length of stay was divided into two categories: acute and medical stable. The summation of the number days medical stable category was used to estimate the increased patient throughput had those unwarranted days been eliminated.

Physician rounding times, admission times, and discharge times were investigated. Average admission and discharge times were calculated by unit and arrayed with average rounding times and the number of beds per unit. Descriptive statistics and the difference between rounding, admission, and discharge times were calculated to demonstrate the potential for a faster discharge process.

The length of care analysis was conducted by comparing lengths of stay for each DRG performed on several different wards in order to demonstrate the potential to reduce length of care and increase patient throughput. First, all 481 DRGs performed at the hospital were sorted by descending average length of stay. DRGs with an average length of stay of 6 days or more were considered for analysis. Forty-two percent, or 204 DRGs, made the first cut. From there, another subset list was developed using the median number of cases. Since the median number of cases among all DRGs was 19, only DRGs with 20 more cases were examined. Almost 49% of the DRGs with lengths of stay of six days or more also had 20 or more cases performed at the hospital. This restriction brought the list down to 99 DRGs. A series of linear regression models were estimated to evaluate the relationship between length of stay and patient demographics such as sex, race, and age at discharge. Additionally, the location or hospital unit performing the care served as predictors. Finally, the potential impact to patient throughput was calculated using a binary excessive or normal length of stay variable. The summation of all the patient days greater than 6 days length of stay divided by the average length of stay was used to show the potential increased throughput if excessive lengths of stay were eliminated.

Results

Descriptive statistics for monthly admissions, discharges, average daily census, occupancy percentages, and length of stay broken down by unit are displayed in Table 2. Ben Taub averaged almost 2,000 admissions per month and maintained over 78% occupancy. A very busy emergency room and surgical schedule feed an already robust patient throughput system causing frequent system back-ups resulting in emergency center diversions.

Table 2. *Descriptive Statistics: Monthly Inpatient Activities, March 2001 - July 2003*

	N	*M*	*Min*	*Max*	*SD*
Admissions	29	1,989.72	1,797	2,262	102.207
Percent Occupancy	29	78.38	70.27	86.27	3.207
EC Visit - Surgical	29	2,337.93	1,825	2,695	206.467
EC Visit - Medical	29	2,986.14	2,531	3,271	188.925
Clinic Visits	29	12,778.38	10,631	15,084	993.632
OR Procedures	29	899.83	799	1,058	60.319
Avg. Daily Census	29	381.72	342.19	420.13	15.617
Discharge Days	29	11,812.38	9,851	15,617	1,079.406
Avg. Length of Stay	29	5.97	5.39	7.93	.465
Discharges	29	1,978.14	1,788	2,249	116.576
Patient Days	29	11,625.79	10,421	13,024	635.162

Emergency center diversions arranged by day of the week are displayed in Table 3 and shows more than 25% of the diversion hours are on Mondays. Backer (2002) and Karpiel (2000) urge the examination of time data by the day of the week. However, Chan, Reily, and Salluzzo (1997), were not able to show a day of the week relationship. Under the null of equal expected frequencies, an analysis of Ben Taub's EC diversions and day of the week provided strong support for the alternative: $\chi^2(6, n = 299) = 13$, $p < .05$ for frequency and $\chi^2(6, n = 299) = 387$, $p < .001$ for time indicating a day of the week difference. Ben Taub's EC diversions are not random but are a result of the patient throughput process.

Table 3. *Emergency Center Diversions by Weekday, January 2003 - August 2003*

	Diversions		Total Time	
	N	Percent	Hours:Minutes	Percent
Sunday	39	13.04%	304:32	9.85%
Monday	59	19.73%	793:06	25.65%
Tuesday	51	17.06%	518:22	16.76%
Wednesday	40	13.36%	373:01	12.06%
Thursday	31	10.37%	359:46	11.63%
Friday	35	11.71%	347:07	11.23%
Saturday	44	14.72%	396:17	12.82%
Total	299	100.00%	3092:11	100.00%

Appropriateness of the input or admission is therefore important. The number of observation patients admitted to inpatient beds is displayed in Table 4. In the last 12 months, Ben Taub has cared for 388 observation patients. The average length of stay is 20 hours 18 minutes cumulating into more than 328 patient days. Thirty-six percent of observation patients stayed more than the allotted 23-hour observation period and accounted for more than 40 patient days.

Table 4. *Descriptive Statistics: Observation Patients Length of Stay (LOS)*

	LOS	Extra Time Above 23 Hours
N	388	139
Mean	20:18	06:59
Minimum	00:01	00:00
Maximum	7 13:45	6 13:45
Sum	328 09:08	40 12:05
Std. Dev.	13:32	15:09

Note: Time format ddd hh:mm;

Cross tabulations of observation patients in Table 5 and Table 6 summarize the excess stay by month and location, respectively. A summertime pattern emerges where the percent of excessive length of stay rises to a peak in August and drops to a low in January. More than 61% of the excessive stays occur in Obstetrics and Pediatric critical care wards (3A-3C, 5E, and 5G). Goodness of fit tests were used to determine if a difference exists between the actual number of observation patients and the expected number of patients on a monthly basis. Observation patients with 23-hours or more, $\chi^2(11, n = 139) = 210.2$, $p < .001$, shows length of stay is strongly related to month. When excessive length of stay for observation patient is examined by location of stay, $\chi^2(18, n = 139) = 162.1$, $p < .001$, a strong relationship emerges indicating that some locations are better at adhering to the 23 hour maximum stay than other locations.

Table 5. *Cross Tabulations: Observation Patients by Month*

	Stay 23+ hours		
Month	No	Yes	Total
September 2002	12	10	22
October 2002	19	13	32
November 2002	28	10	38
December 2002	15	6	21
January 2003	19	5	24
February 2003	19	7	26
March 2003	22	10	32
April 2003	23	12	35
May 2003	19	14	33
June 2003	31	18	49
July 2003	27	18	45
August 2003	15	16	31
Total	249	139	388

Table 6. *Cross Tabulations: Observation Patients by Location*

LOCATION	Stay 23+ hours No	Stay 23+ hours Yes	Total
Unit 3A	0	3	3
Unit 3B	20	16	36
Unit 3C	50	29	79
Unit 3F	49	0	49
Unit 4A	5	8	13
Unit 4B	9	10	19
Unit 4D	0	1	1
Unit 4E	1	0	1
Unit 5A	7	9	16
Unit 5B	1	4	5
Unit 5C	5	8	13
Unit 5E	21	16	37
Unit 5F	4	0	4
Unit 5G	29	21	50
Unit 6A	1	1	2
Unit 6B	1	1	2
Discharge Holding	7	6	13
Emergency Center	9	6	15
Other	30	0	30
Total	249	139	388

Complementing the appropriateness of admission, or input in the system, the steadiness of outflow must be maintained. Long stay patients can hinder the capacity of the system. The long stay patient level analysis summarized in Table 7 shows an average length of stay over 113 days. The 32 patients tracked in this analysis accounted for 3,630 inpatient days; 2,064 of which were considered medically stable and therefore could have been safely discharged. In other words, almost 57% of their cumulative stay was not medically necessary and almost certainly not reimbursed.

Table 7. *Descriptive Statistics: Long Stay Patients Discharges, 25 March 2003 - 30 September 2003*

	Acute LOS	Stable LOS	Total LOS
Sum	1,566.00 days	2,064.00 days	3,630.00 days
Mean	48.94 days	64.50 days	113.44 days
Percent	43.14%	56.86%	100.00%

Note: *n* = 32; Length of Stay (LOS)

Physician rounding times, average admission times, and average discharge times, and the number of beds for each department are arrayed in Table 8 and 9. Critical care beds are displayed in Table 8 and conventional patient care type beds are displayed in Table 9.

Table 8. *Critical Care Services Operational Fundamentals*

Service	Location	Number of Beds	Round Start Times	Average Admission Time	Average Discharge Time
Total		151			
Neonatal ICU	3E	20	09:30	12:01	14:58
Telemetry (Surg)	4B	4	06:30	12:28	16:30
Neurology ICU	4C	16	06:00	12:40	14:12
Critical Wound Unit	4D	10	06:00	12:25	14:57
Surgical ICU	4E	30	06:00	12:16	14:25
Pediatric ICU	5F	10	07:30	13:11	16:02
Pediatric IMC	5G	16	07:30	13:01	15:59
Telemetry (Med)	6D	21	08:00	13:24	17:16
Medicine ICU	6E	16	08:00	13:29	13:08
Coronary Care Unit	6F	8	08:00	13:04	14:45
Average			07:18	12:47	15:13

Note: 647 licensed beds; 588 staffed beds; 151 critical care beds

Table 9. *Conventional Inpatient Services Operational Fundamentals*

Service	Location	Number of Beds	Round Start Times	Average Admission Time	Average Discharge Time
Total		437			
Postpartum	3A	36	06:30	12:01	16:54
OB High Risk	3B	36	06:30	11:52	17:00
OB High Risk	3C	12	06:30	14:32	15:34
Nursery Level II	3D	34	09:00	12:11	17:50
Labor & Delivery	3F	12	08:00	12:50	12:54
Nursery Level I	3G	16	08:30	13:13	16:00
Surg Ward (Med)	4A	34	06:30	12:42	15:53
Surg Ward (Med) (+4 Telemetry)	4B	30	06:30	12:28	16:30
Medicine Ward	5A	33	06:30	12:37	17:00
Med/Surg (Ortho)	5B	33	08:30	12:42	16:17
Medicine/Neuro	5C	32	06:00	12:49	16:46
Medicine (10 Geriatrics)	5D	22	08:00	13:01	16:22
Pediatric Ward	5E	30	10:00	13:35	16:46
Medicine Ward	6A	33	07:00	13:24	17:15
Medicine Ward (4 Radiation)	6B	32	08:00	12:53	17:03
Medicine Ward (+21 Telemetry)	6D	12	08:00	13:24	17:16
Average			07:30	12:53	16:27

Note: 647 licensed beds; 588 staffed beds; 437 conventional beds

Table 10 examines the difference between physician rounding times, admission times, and discharge times. The difference in the overall average discharge time and admission time is over 4 hours. The difference between the average discharge time and the average rounding time is more than 9 hours.

Table 10. *Descriptive Statistics: Physician Rounding Analysis Differences in Overall Average Times*

	(A) Physician Rounding Time	(B) Admission Time	(C) Discharge Time	Difference (C-B)	Difference (C-A)
N	26	29,803	29,803		
Mean	07:25	12:32	16:40	4:08	9:15
Median	07:30	12:58	17:00	6:02	9:30
Mode	06:30	06:00	18:00	12:00	11:30

After examining the inputs and outputs to the patient care system, the length of the care itself was examined. Table 11 displays demographic information for patients who were discharged between September 2002 and August 2003. African Americans and Hispanics comprise almost 83% of the patients.

Table 11. *Descriptive Statistics:*
Demographics of Discharged Case, September 2002 - August 2003

Variable	*N*	Percent
Total	119,268	100.0%
Patient Type		
Emergency	89,465	75.0%
Inpatient	29,803	25.0%
Sex		
Male	55,942	46.9%
Female	61,787	51.8%
Unknown	1,539	1.3%
Race		
Asian	2,267	1.9%
African American	41,643	34.9%
Hispanic	57,279	48.0%
Indian (American)	258	.2%
White	15,452	13.0%
Other	2,369	2.0%

Table 12 compares the overall inpatient sample to only those patients that stayed longer than the average 6 days. Over 79% of the inpatients stay less than 6 days demonstrating some skewness in the data. Lee, Fung and Fu (2003) recognized that length of stay is naturally positively skewed and the median is a better measure than the mean. Using the median eliminates the need to trim the data and remove outliers or extremely long patient stays. Table 12 confirms that the median is a better measure. The median associated with the whole sample is 2.77 days. Elimination or trimming 21% of cases with lengths of stay greater than 6 days brings the mean down to 2.63 days.

Table 12. *Descriptive Statistics. Inpatient Length of Stay, September 2002 - August 2003*

	N	*M*	*Mdn*	*Mode*	*SD*
All Inpatient	29,803	5.45	2.77	2.33	11.07
Inpatient LOS Below 6 days	23,618	2.63	2.39	2.33	1.22

Ninety-nine DRGs were tested, using linear regressions as describe above, for significance at the alpha level $p < .05$ to demonstrate the potential for reduction of the length of care. Table 13 displays length of stay descriptive statistics for the 36 DRGs that exhibited significant differences at or beyond the $p < .05$ significant threshold. DRG 386 (Extreme immaturity - Neonate) and 483 (Tracheotomy, not mouth or neck) show very high average lengths of stay at 68 and 73 days respectively. Inferential statistics are displayed in Table 14. The most powerfully significant group of DRGs are all related to newborns (385-389). Many of the estimated regression coefficients demonstrate how location or treating hospital unit affects the length of stay. The implications of these models are discussed in the next section.

Table 13. *Descriptive Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

DRG	*N*	*M*	*Mdn*	*SD*
24	75	7.18	4.40	11.591
28	48	7.62	4.09	8.876
34	28	8.89	3.82	14.22
75	57	16.31	11.86	14.992
89	143	6.17	4.67	5.269
114	22	8.48	5.25	9.152
121	53	9.79	8.11	5.762
127	436	6.31	4.27	6.338
148	115	12.60	8.10	11.383
157	26	6.66	3.45	13.201
177	20	6.96	3.54	8.106
197	20	16.26	8.21	21.090
198	32	7.03	5.90	3.885
210	33	13.94	9.30	14.540
218	55	11.07	8.41	11.187
223	23	6.63	5.05	5.416
231	49	11.55	6.07	23.870
240	40	9.66	6.16	11.060

Note: Median number of cases per DRG is 19, therefore DRGs with 20 or more cases considered in analysis. Significance threshold used: $p < .05$

Table 13 (continued). *Descriptive Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

DRG	*N*	*M*	*Mdn*	*SD*
253	27	8.40	3.06	22.615
269	63	7.29	5.02	6.955
274	21	6.77	6.04	3.787
320	112	6.70	5.21	6.363
356	28	9.95	2.41	40.208
385	63	11.17	1.12	29.516
386	82	68.64	48.59	73.248
387	131	20.77	16.78	17.993
388	228	6.77	3.79	8.533
389	219	6.82	4.16	7.472
415	51	17.49	11.33	18.480
423	23	10.85	7.01	8.185
442	30	10.58	6.15	11.010
470	28	6.44	4.87	4.329
473	30	16.78	12.65	16.660
475	123	12.30	8.00	13.587
478	22	17.58	14.35	16.072
483	125	73.67	57.89	63.197
486	102	14.94	10.56	15.495

Note: Median number of cases per DRG is 19, therefore DRGs with 20 or more cases considered in analysis. Significance threshold used: $p < .05$

Table 14. *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		*SE*
LOS (DRG 24)	(Constant)	10.671	*	4.800
	Females	-.788		2.749
	African-American	-4.244		2.822
	Hispanic	.755		3.208
	Age at Discharge	-.053		.091
	Unit 4A	5.479		10.128
	Unit 4B	3.635		7.228
	Unit 4E	-4.598		10.164
	Unit 5A	-4.790		7.291
	Unit 5B	-.340		5.895
	Unit 5D	32.407	***	5.422
	Unit 5G	-7.326		10.389
	Unit 6A	4.058		5.952
	Unit 6B	-2.208		3.376
	Unit 6D	-3.052		5.457
	Unit 6E	-3.945		7.465
	Unit 6F	-6.216		7.936
	Unit - Other	-3.770		4.695
$F(17,57)$	= 2.86**			

Note: *p < .05, **p < .01, ***p < .001; excluded variables: Males, White, Unit 5C

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		*SE*
LOS (DRG 28)				
	(Constant)	1.694		5.373
	Females	3.104		4.140
	African-American	-6.241		3.147
	Hispanic	-6.069		3.343
	Race - Other	-13.612		9.455
	Age at Discharge	.145		.096
	Unit 4B	4.668		4.037
	Unit 4C	-.671		3.941
	Unit 4E	4.419	***	4.282
	Unit 5A	24.792		5.652
	Unit 5B	-4.249		7.721
	Unit 5D	-3.835		6.423
	Unit 6A	5.510		7.863
	Unit - Other	4.493		3.379
$F(13,34)$	= 3.15**			

Note: *p < .05, **p < .01, ***p < .001; excluded variables: Males, White, Unit 4A

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		*SE*
LOS (DRG 34)				
	(Constant)	4.473		3.961
	Females	-1.066		6.322
	Asian	-74.704	**	16.007
	African-American	-4.859		11.124
	White	2.584		9.335
	Age at Discharge	.065		.179
	Unit 4A	-6.391		15.386
	Unit 4B	-4.018		7.317
	Unit 4C	-.050		13.802
	Unit 5A	8.650		14.024
	Unit 5B	-7.271		15.309
	Unit 5C	-4.956		12.024
	Unit 5D	-4.473		11.490
	Unit 5E	-4.036		8.438
	Unit 5F	70.969	**	14.716
	Unit 6A	21.867		14.227
	Unit 6B	12.205		13.434
	Unit 6D	2.404		14.082
	Unit 6E	-5.731		16.012
	Unit 6F	6.575		14.220
	Unit - Other	-1.873		14.991
$F(20,7)$	= 4.35*			

Note: $*p < .05$, $**p < .01$, $***p < .001$; excluded variables: Males, Hispanic, Unit 5G

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		*SE*
LOS (DRG 75)				
	(Constant)	6.945		6.221
	Females	-11.860	*	5.110
	Asian	31.466	***	9.228
	African-American	14.630	**	4.405
	White	4.368		7.238
	Race - Other	6.911		14.886
	Age at Discharge	.136		.153
	Unit 4A	3.435		6.356
	Unit 4D	1.094		10.331
	Unit 4E	-2.226		5.392
	Unit 5D	10.371		10.004
	Unit 5E	15.799		15.381
	Unit 5G	8.783		10.830
	Unit 6A	2.989		9.470
	Unit 6B	-10.894		7.641
	Unit - Other	-15.859	*	7.828
$F(15,41)$	= 1.98*			

Note: $*p < .05$, $**p < .01$, $***p < .001$; excluded variables: Males, Hispanic, Unit 4B

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		*SE*
LOS (DRG 89)				
	(Constant)	2.063		2.172
	Females	-.894		.964
	Asian	-1.748		3.182
	Hispanic	.635		1.076
	White	.519		1.128
	Race - Other	3.093		5.207
	Age at Discharge	.066	*	.033
	Unit 4A	11.938	**	3.745
	Unit 4B	2.480		2.153
	Unit 5A	.015		1.683
	Unit 5B	8.633	**	2.752
	Unit 5C	2.734		1.633
	Unit 5D	.196		1.684
	Unit 6A	-1.124		1.348
	Unit 6D	-.815		1.820
	Unit 6E	-4.186		3.690
	Unit - Other	-1.556		1.463
$F(16,126)$	= 2.01*			

Note: *p < .05, **p < .01, ***p < .001; excluded variables: Males, African-American, Unit 6B

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β	SE
LOS (DRG 114)			
	(Constant)	2.777	11.967
	Females	-1.608	4.219
	Hispanic	1.837	4.104
	White	-.418	8.541
	Age at Discharge	.029	.175
	Unit 4B	3.068	3.815
	Unit 4D	.707	7.598
	Unit 5A	2.498	7.198
	Unit 5B	3.137	6.308
	Unit 5D	29.136 **	7.106
	Unit 6A	1.208	7.654
	Unit - Other	-1.724	5.695
$F(11,10)$	= 3.32*		

Note: *p < .05, **p < .01, ***p < .001; excluded variables: Males, African-American, Unit 4A

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		*SE*
LOS (DRG 121)				
	(Constant)	3.510		3.852
	Females	-.497		1.783
	Asian	6.280		3.568
	Hispanic	-.987		2.158
	White	-3.745		2.384
	Age at Discharge	.108		.066
	Unit 4B	-1.940		5.977
	Unit 5B	13.403	*	5.403
	Unit 5C	2.255		2.816
	Unit 5D	1.674		2.971
	Unit 6A	4.512	*	2.168
	Unit 6B	3.175		2.532
	Unit 6F	-8.936	*	4.297
	Unit - Other	-2.399		2.331
$F(13,39)$	= 2.24*			

Note: *p < .05, **p < .01, ***p < .001; excluded variables: Males, African-American, Unit 6D

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		*SE*
LOS (DRG 127)				
	(Constant)	4.166	**	1.512
	Females	-.154		.638
	Asian	.232		2.378
	Hispanic	-.942		.699
	Indian (American)	-2.154		4.471
	White	-.557		.949
	Race - Other	5.063		3.704
	Age at Discharge	.033		.024
	Unit 4A	-1.806		3.627
	Unit 4B	-1.205		1.356
	Unit 5A	-.136		1.505
	Unit 5B	-.181		2.835
	Unit 5C	.689		1.187
	Unit 5D	4.803	***	1.132
	Unit 6A	-.250		1.072
	Unit 6B	1.095		.948
	Unit 6E	5.283		3.642
	Unit 6F	-2.447		2.679
	Unit - Other	-.705		1.032
$F(18,417)$	= 2.37***			

Note: *p < .05, **p < .01, ***p < .001; excluded variables: Males, African-American, Unit 6D

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		*SE*
LOS (DRG 148)				
	(Constant)	8.770	**	3.259
	Females	-.288		2.309
	Asian	-5.539		7.258
	African-American	.432		2.508
	White	-2.219		2.625
	Race - Other	15.088	*	7.320
	Age at Discharge	.051		.072
	Unit 4A	1.293		2.358
	Unit 4E	3.006		3.787
	Unit 5A	1.656		7.416
	Unit 5B	-1.422		7.367
	Unit 5C	-2.806		10.112
	Unit 5D	33.422	***	5.573
	Unit 5G	.421		7.522
	Unit 6A	3.821		10.077
	Unit 6B	1.083		7.305
	Unit - Other	-.406		2.829
$F(16,98)$	= 3.47***			

Note: *p < .05, **p < .01, ***p < .001; excluded variables: Males, Hispanic, Unit 4B

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		SE
LOS (DRG 157)				
	(Constant)	9.301	**	2.831
	Females	.911		2.106
	African-American	-1.025		1.424
	White	-1.494		2.284
	Age at Discharge	-.091		.060
	Unit 3F	-3.294		3.469
	Unit 4A	-3.159		1.999
	Unit 4D	6.775	*	2.744
	Unit 4E	-1.097		3.379
	Unit 5A	-1.003		2.648
	Unit 5C	1.802		3.380
	Unit 5D	67.652	***	3.905
	Unit 6A	6.132		3.664
	Unit 6D	-1.050		2.753
	Unit 6F	1.521		3.442
	Unit - Other	-2.845		1.508
$F(15,10)$	= 52.02**			

Note: $*p < .05$, $**p < .01$, $***p < .001$; excluded variables: Males, Hispanic, Unit 4B

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		*SE*
LOS (DRG 177)				
	(Constant)	6.711		5.243
	Females	4.082		6.566
	Hispanic	-2.856		2.900
	White	-4.698		3.883
	Age at Discharge	.030		.085
	Unit 4B	.043		5.294
	Unit 4E	-3.983		4.683
	Unit 5A	-5.764		4.981
	Unit 5C	-5.762		4.965
	Unit 5D	-1.459		3.108
	Unit 6B	-.593		2.947
	Unit 6D	28.264	***	5.245
	Unit - Other	17.072	*	4.940
$F(12,7)$	= 5.62*			

Note: $*p < .05$, $**p < .01$, $***p < .001$; excluded variables: Males, African-American, Unit 6A

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		*SE*
LOS (DRG 197)				
	(Constant)	17.269		15.645
	Females	-4.278		4.515
	African-American	49.382	**	13.987
	Hispanic	-2.417		6.747
	White	-6.600		8.738
	Age at Discharge	-.083		.193
	Unit 4A	13.689		6.303
	Unit 5A	7.139		8.578
	Unit 5D	12.027		10.108
	Unit 6A	6.345		9.499
	Unit 6B	15.294		14.408
	Unit - Other	-4.305		6.120
$F(11,8)$	= 12.05***			

Note: $*p < .05$, $**p < .01$, $***p < .001$; excluded variables: Males, Asian, Unit 4B

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		*SE*
LOS (DRG 198)				
	(Constant)	4.995		4.098
	Females	.174		1.173
	Asian	3.303		3.373
	Hispanic	2.168		2.065
	White	1.503		2.429
	Race - Other	17.566	***	3.438
	Age at Discharge	.013		.053
	Unit 3B	-3.686		2.806
	Unit 4B	-1.850		1.433
	Unit 5A	-2.537		1.634
	Unit 5C	.551		3.359
	Unit - Other	.109		1.415
$F(11,20)$	= 4.60**			

Note: $*p < .05$, $**p < .01$, $***p < .001$; excluded variables: Males, African-American, Unit 4A

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		*SE*
LOS (DRG 210)				
	(Constant)	-3.292		5.853
	Females	8.693	*	3.549
	Asian	3.311		9.208
	African-American	.554		4.734
	Hispanic	11.565	*	4.521
	Age at Discharge	.229		.111
	Unit 4B	10.101		9.277
	Unit 4E	-3.823		9.058
	Unit 5A	-7.652		4.906
	Unit 5C	-11.094		9.707
	Unit 5D	-1.863		7.652
	Unit 6B	46.799	***	10.818
	Unit - Other	-5.119		5.351
$F(12,20)$	= 6.01***			

Note: *p < .05, **p < .01, ***p < .001; excluded variables: Males, White, Unit 5B

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		*SE*
LOS (DRG 218)				
	(Constant)	-4.711		4.408
	Females	-.447		3.044
	African-American	2.600		3.584
	White	1.826		3.365
	Age at Discharge	.323	***	.079
	Unit 4A	-3.231		5.394
	Unit 4B	2.836		5.827
	Unit 4E	4.547		10.055
	Unit 5A	-1.284		6.055
	Unit 5C	.763		5.259
	Unit 5D	5.858		10.492
	Unit 6B	22.262	*	9.949
	Unit - Other	-.311		4.844
$F(12,42)$	= 2.59*			

Note: *p < .05, **p < .01, ***p < .001; excluded variables: Males, Hispanic, Unit 5B

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		*SE*
LOS (DRG 223)				
	(Constant)	1.886		2.486
	Females	5.334		2.675
	Asian	.642		2.784
	African-American	-5.821	*	2.627
	White	-4.018	*	1.837
	Age at Discharge	.093		.065
	Unit 4B	2.270		2.050
	Unit 5A	.156		2.000
	Unit 5C	1.274		2.518
	Unit 5D	13.755	***	3.056
	Unit - Other	-2.584		1.416
$F(10,12)$	= 9.98***			

Note: *p < .05, **p < .01, ***p < .001; excluded variables: Males, Hispanic, Unit 5B

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		*SE*
LOS (DRG 231)				
	(Constant)	4.469		3.746
	Females	-2.160		2.782
	Asian	-3.644		5.196
	African-American	3.160		2.372
	White	2.148		2.804
	Age at Discharge	.102		.080
	Unit 4A	-2.111		4.399
	Unit 4B	-3.847		2.776
	Unit 4D	9.887		4.898
	Unit 5C	-4.856		3.738
	Unit 5D	155.922	***	7.031
	Unit 5E	-3.488		5.320
	Unit 6B	-.664		6.625
	Unit 6D	-6.670		6.724
	Unit - Other	.754		2.605
$F(14,34)$	= 47.60***			

Note: $*p < .05$, $**p < .01$, $***p < .001$; excluded variables: Males, Hispanic, Unit 5B

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		*SE*
LOS (DRG 240)				
	(Constant)	-3.034		5.536
	Females	1.458		3.446
	Asian	1.844		6.819
	African-American	5.758		3.527
	White	18.435		8.994
	Age at Discharge	.138		.102
	Unit 4A	8.493		8.964
	Unit 4B	-7.811		9.034
	Unit 5A	2.628		5.813
	Unit 5B	24.793	*	8.961
	Unit 5C	6.408		5.655
	Unit 5D	8.119		5.378
	Unit 5E	4.883		9.610
	Unit 6A	2.629		6.261
	Unit 6D	.616		4.565
	Unit 6E	44.174	***	9.033
	Unit - Other	-2.311		4.569
$F(16,23)$	= 3.05**			

Note: $*p < .05$, $**p < .01$, $***p < .001$; excluded variables: Males, Hispanic, Unit 6B

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		*SE*
LOS (DRG 253)				
	(Constant)	4.273		2.103
	Females	-.058		1.881
	Asian	114.966	***	4.016
	Hispanic	-.899		1.674
	White	-1.351		1.964
	Age at Discharge	-.004		.029
	Unit 4A	-.615		1.811
	Unit 4B	1.623		1.677
	Unit 4E	-.079		2.994
	Unit 5A	.109		2.208
	Unit 5C	-1.043		2.857
	Unit 5D	1.072		2.910
	Unit 6A	1.597		3.361
	Unit 6D	15.913	***	2.846
	Unit - Other	-.730		2.120
$F(14,12)$	= 146.42***			

Note: *p < .05, **p < .01, ***p < .001; excluded variables: Males, African-American, Unit 5B

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		*SE*
LOS (DRG 269)				
	(Constant)	3.165		2.700
	Females	1.752		2.065
	Asian	2.950		8.956
	African-American	1.619		2.045
	White	-1.690		2.152
	Age at Discharge	.077		.063
	Unit 3B	-6.204		6.585
	Unit 4B	1.211		1.996
	Unit 4D	-3.254		6.492
	Unit 4E	-.575		6.481
	Unit 5A	-2.147		3.900
	Unit 5B	1.160		4.058
	Unit 5C	-3.186		6.466
	Unit 5D	-5.169		6.424
	Unit 5E	21.579	***	4.972
	Unit 6A	10.718		6.523
	Unit - Other	-2.386		2.560
$F(16,46)$	= 2.10*			

Note: *p < .05, **p < .01, ***p < .001; excluded variables: Males, Hispanic, Unit 4A

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		*SE*
LOS (DRG 274)				
	(Constant)	5.692		2.655
	Asian	-6.968	*	2.918
	African-American	-6.130	**	1.378
	White	-3.838		2.868
	Race - Other	-6.690	*	2.539
	Age at Discharge	.065		.038
	Unit 4A	4.429	*	1.702
	Unit 5A	3.503		1.743
	Unit 5B	6.621	*	2.290
	Unit 5C	-6.366	*	1.923
	Unit 6B	3.040		1.800
	Unit 6D	3.069		3.441
	Unit 6E	8.667	**	2.281
	Unit - Other	2.448		2.392
$F(13,7)$	= 4.64*			

Note: $*p < .05$, $**p < .01$, $***p < .001$; excluded variables: Hispanic, Unit 6A

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		*SE*
LOS (DRG 320)				
	(Constant)	3.866		2.687
	Females	-1.930		1.204
	Asian	10.124	**	3.613
	Hispanic	.357		1.366
	White	2.856		2.161
	Race - Other	.297		4.405
	Age at Discharge	.051		.036
	Unit 4B	.297		3.222
	Unit 5A	-.621		1.943
	Unit 5B	-1.085		6.089
	Unit 5C	-.771		2.037
	Unit 5D	4.518	*	1.918
	Unit 6A	1.594		1.708
	Unit 6D	2.100		2.881
	Unit - Other	1.193		2.888
$F(14,97)$	= 2.30**			

Note: *p < .05, **p < .01, ***p < .001; excluded variables: Males, African-American, Unit 6B

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		*SE*
LOS (DRG 356)				
	(Constant)	1.735		1.354
	African-American	.767		.718
	Indian (American)	.130		1.778
	White	-.210		.722
	Age at Discharge	.017		.023
	Unit 4A	-1.494		1.303
	Unit 4B	212.179	***	1.318
	Unit 5A	-1.562		.803
	Unit 5B	-1.397		1.366
	Unit - Other	-3.525	*	1.462
$F(9,19)$	= 3066.73***			

Note: *p < .05, **p < .01, ***p < .001; excluded variables: Hispanic, Unit 3B

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		*SE*
LOS (DRG 385)				
	(Constant)	.103		.069
	Females	-.107		.107
	Asian	.628		.379
	African-American	.005		.130
	White	-8.578	***	.381
	Age at Discharge	365.828	***	.679
	Unit 3D	-.344		.255
	Unit 3G	-.146		.227
	Unit 5F	-2.959	***	.381
$F(8,54)$	= 48143.10***			

Note: *p < .05, **p < .01, ***p < .001; excluded variables: Males, Hispanic, Unit 3E

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		*SE*
LOS (DRG 386)				
	(Constant)	-.207		.914
	Females	-1.650		1.164
	African-American	1.161		1.413
	White	1.598		2.894
	Age at Discharge	366.318	***	3.240
	Unit 3G	.377		5.036
	Unit 5F	-2.234		5.962
	Unit 5G	.359		2.872
$F(7,74)$	= 2671.49***			

Note: *p < .05, **p < .01, ***p < .001; excluded variables: Males, Hispanic, Unit 3D

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		*SE*
LOS (DRG 387)				
	(Constant)	.339		.743
	Females	.461		.730
	Asian	.398		2.840
	African-American	.353		1.166
	White	-.545		3.986
	Race - Other	.798		3.998
	Age at Discharge	351.324	***	7.276
	Unit 3A	-.462		2.050
	Unit 3B	.218		4.012
	Unit 3E	-.070		4.014
	Unit 3G	.045		2.878
	Unit 5G	.843		2.021
$F(11,199)$	= 234.50***			

Note: *p < .05, **p < .01, ***p < .001; excluded variables: Males, Hispanic, Unit 3D

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		*SE*
LOS (DRG 388)				
	(Constant)	.218	***	.066
	Females	.031		.064
	Asian	.039		.345
	African-American	-.049		.112
	White	-.032		.245
	Race - Other	.158		.340
	Age at Discharge	364.116	***	1.458
	Unit 3A	-.002		.081
	Unit 3B	-.235	*	.095
	Unit 3E	.548		.483
	Unit 3G	-.135		.122
	Unit 5G	-4.169	***	.478
$F(11,216)$	= 6652.31***			

Note: *$p < .05$, **$p < .01$, ***$p < .001$; excluded variables: Males, Hispanic, Unit 3D

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	*β*		*SE*
LOS (DRG 389)				
	(Constant)	4.052	***	.618
	Females	.047		.651
	Asian	-.638		1.926
	African-American	-.937		1.117
	Indian (American)	-.893		4.707
	White	-.765		3.287
	Age at Discharge	219.523	***	12.656
	Unit 3A	-2.683	**	.951
	Unit 3B	-2.724	*	1.268
	Unit 3E	-1.897		2.655
	Unit 3G	-1.387		1.328
	Unit 5E	-12.946	***	1.276
	Unit 5G	-12.318	***	1.089
	Unit - Other	-12.701	**	4.579
$F(13,205)$	= 30.03***			

Note: *p < .05, **p < .01, ***p < .001; excluded variables: Males, Hispanic, Unit 3D

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		*SE*
LOS (DRG 415)				
	(Constant)	4.328		8.969
	Females	4.593		6.385
	Asian	-22.572		17.032
	African-American	2.373		6.188
	White	-3.092		8.070
	Age at Discharge	.109		.202
	Unit 3B	-7.053		9.814
	Unit 4A	2.815		8.126
	Unit 4D	34.313	***	9.033
	Unit 4E	-6.834		11.548
	Unit 5A	-6.042		10.003
	Unit 5B	-3.731		12.172
	Unit 5C	24.422		15.540
	Unit 5D	13.097		12.203
	Unit 5E	28.242	*	10.988
	Unit 6A	24.129	*	10.079
	Unit 6E	20.994		21.794
	Unit 6F	5.489		15.959
	Unit - Other	-8.324		15.364
$F(18,32)$	= 2.94**			

Note: $*p < .05$, $**p < .01$, $***p < .001$; excluded variables: Males, Hispanic, Unit 4B

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		*SE*
LOS (DRG 423)				
	(Constant)	-8.092		7.189
	Females	9.113	*	3.501
	Asian	33.782	***	7.464
	Hispanic	4.312		3.721
	White	8.022		3.675
	Age at Discharge	.290	*	.103
	Unit 4A	-26.000	*	9.553
	Unit 5A	-11.652		6.480
	Unit 5D	7.431		3.800
	Unit 5E	8.671		6.629
	Unit 5F	3.298		7.239
	Unit 6A	-11.552	*	3.936
	Unit 6B	-4.694		4.537
	Unit 6E	-7.050		7.110
$F(13,9)$	= 4.38*			

Note: $*p < .05$, $**p < .01$, $***p < .001$; excluded variables: Males, African-American, Unit 5C

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		*SE*
LOS (DRG 442)				
	(Constant)	-.329		7.558
	Females	-7.841		3.935
	African-American	7.826		4.144
	White	2.205		4.816
	Age at Discharge	.177		.151
	Unit 3B	18.541	*	8.650
	Unit 4A	-1.255		4.815
	Unit 4D	-5.048		5.881
	Unit 4E	19.426	*	8.524
	Unit 5A	17.694	*	8.200
	Unit 5B	-4.154		6.652
	Unit 5D	40.379	***	8.566
	Unit 6A	-4.077		8.269
	Unit - Other	-4.101		6.317
$F(13,16)$	= 4.23**			

Note: *p < .05, **p < .01, ***p < .001; excluded variables: Males, Hispanic, Unit 4B

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		*SE*
LOS (DRG 470)				
	(Constant)	5.656		3.630
	Females	-1.803		1.977
	Hispanic	-.246		1.941
	White	-4.222		2.286
	Age at Discharge	.017		.050
	Unit 3B	-1.549		2.994
	Unit 4B	.055		2.300
	Unit 4D	11.923	**	3.504
	Unit 5B	1.414		3.376
	Unit 5C	2.124		3.001
	Unit 5E	9.271		4.962
	Unit 6A	5.035		2.659
	Unit 6B	2.741		2.601
	Unit - Other	3.899		2.450
$F(13,14)$	= 2.92*			

Note: $*p < .05$, $**p < .01$, $***p < .001$; excluded variables: Males, African-American, Unit 6D

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		*SE*
LOS (DRG 473)				
	(Constant)	-4.731		11.140
	Females	-3.713		6.306
	African-American	-6.873		10.802
	White	-10.737		8.372
	Age at Discharge	.458		.283
	Unit 4A	-20.631		15.230
	Unit 5A	6.914		9.070
	Unit 5B	19.285		10.036
	Unit 5C	5.233		7.781
	Unit 5D	50.887	**	15.088
	Unit 6A	14.520		7.923
	Unit 6D	-6.867		10.129
	Unit 6E	2.957		10.506
$F(12,17)$	= 2.81*			

Note: *p < .05, **p < .01, ***p < .001; excluded variables: Males, Asian, Hispanic, Unit 6B

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		*SE*
LOS (DRG 475)				
	(Constant)	-2.992		6.143
	Females	-1.229		2.714
	Asian	22.561	*	9.840
	Hispanic	6.165		3.746
	White	.742		3.278
	Race - Other	13.735		13.324
	Age at Discharge	.109		.096
	Unit 4A	-3.329		13.794
	Unit 4B	28.262	***	8.179
	Unit 4E	9.022		8.082
	Unit 5A	7.727		6.702
	Unit 5B	1.457		9.821
	Unit 5C	11.851	*	5.042
	Unit 5D	12.744	*	5.587
	Unit 5E	12.254		11.158
	Unit 5F	8.678		7.574
	Unit 5G	7.260		7.230
	Unit 6A	12.876	**	4.344
	Unit 6B	4.320		4.515
	Unit 6D	15.636	*	7.161
	Unit 6F	8.510		8.205
	Unit - Other	11.243		6.172
$F(21,101)$	= 1.71*			

Note: *p < .05, **p < .01, ***p < .001; excluded variables: Males, African-American, Unit 6E

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		*SE*
LOS (DRG 478)				
	(Constant)	21.346		21.708
	Females	3.519		8.548
	Hispanic	-14.362		6.817
	White	-22.852	*	8.103
	Age at Discharge	.083		.445
	Unit 4A	-5.992		9.840
	Unit 4D	13.342		12.883
	Unit 5C	4.332		8.975
	Unit 5D	33.120	*	12.999
	Unit 6A	-12.019		9.010
	Unit 6D	-7.789		8.755
	Unit - Other	-5.117		7.661
$F(11,10)$	= 3.51*			

Note: *p < .05, **p < .01, ***p < .001; excluded variables: Males, African-American, Unit 4B

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		*SE*
LOS (DRG 483)				
	(Constant)	53.459	*	21.376
	Females	19.965		11.437
	Asian	-6.260		35.121
	African-American	13.231		12.521
	White	7.202		13.783
	Race - Other	78.180		59.407
	Age at Discharge	.074		.359
	Unit 4A	6.359		17.697
	Unit 4C	-19.621		24.520
	Unit 4D	14.558		21.891
	Unit 4E	-13.567		19.641
	Unit 5B	164.228	***	34.788
	Unit 5C	20.344		28.254
	Unit 5D	6.543		31.970
	Unit 5E	-52.976		60.210
	Unit 5F	136.747	**	44.722
	Unit 6A	-3.774		31.023
	Unit 6B	22.157		30.945
	Unit 6D	2.767		18.615
	Unit 6E	-38.676		22.710
	Unit - Other	-32.499		30.443
$F(20,104)$	= 2.77***			

Note: *p < .05, **p < .01, ***p < .001; Males, Hispanic, Unit 4B

Table 14 (continued). *Inferential Statistics: Length of Stay for Significant Diagnostic Related Groups (DRG)*

Model	Factors	β		*SE*
LOS (DRG 486)				
	(Constant)	11.912	**	3.976
	Females	7.878	*	3.855
	Asian	4.729		11.206
	African-American	-.673		3.213
	White	-1.876		4.351
	Race - Other	-2.352		8.525
	Age at Discharge	.003		.092
	Unit 4A	.563		4.217
	Unit 4D	28.327	**	8.660
	Unit 4E	-4.271		4.763
	Unit 5A	9.957		7.561
	Unit 5B	5.247		6.036
	Unit 5C	-.713		14.554
	Unit 5E	37.640	***	10.461
	Unit - Other	-.177		4.195
$F(14,87)$	= 2.51**			

Note: *p < .05, **p < .01, ***p < .001; excluded variables: Males, Hispanic, Unit 4B

Discussion

The length of time that patients remain in the system affects the size of the pool awaiting entrance into the system. Admissions are resource constrained by the availability of beds. Once the beds are full, the input to the patient care system must be diverted or put on hold. Inappropriate admissions needlessly use valuable bed space.

For this reason, the appropriateness of the admission into the system is critical. Observation units closely monitor patients, make admission decisions within 24 hours, control costs, and decrease payment denial (Lenox, & New, 1997). Without a dedicated observation unit, observation patients are currently admitted to any capable bed available. Telemetry capable beds are at a premium for cases such as *rule out myocardial infarction*. An analysis of frequencies of observations by week reveals an average of 7.32 patients per week with a standard deviation 3.496. The median and mode were both exactly 7 patients per week. The maximum number of observation patients in any week was 17. An analysis of frequencies of observation patients per day shows an average of 1.7 patients per day with a standard deviation of 1.002 and a maximum of 9 patients per day.

Staff training on the use of observation status and procedures to upgrade the patient's status to an admission, as needed, will help to reduce the excess observation stay. However, a dedicated observation unit would not normally monitor obstetric patients who would continue to be cared for on the unit. Training would be beneficial particularly in Obstetrics and Pediatrics where 61% of the excessive stays occur.

Like admissions, the discharge process is also critical to the throughput of the system. Medically stable patients able to be discharged but who remain in a bed are, in essence, denying access to other patients. Proudlove et al. (2003) indicate that most system delays occur at discharge.

To reduce the amount and length of long stay patients, Social Workers need to aggressively work toward discharge. The Ben Taub Social Workers are taking steps in the right directions by increasing monitoring and beginning earlier in the process. However, detailed discharge planning including anticipated medications and discharge date needs to begin the very first day of admission (Smith, 2002).

In conjunction with discharge planning, the discharge process, in particular physician rounding times, is of importance to patient throughput. The concept that changing rounding times will reduce wait times can be explained using an illustration. Figure 2 depicts a 4-hour bed gap caused by late discharges. The actual average arrival time for the graph was gathered from EC statistical reports. The admission and discharge curves are hypothetical based on anecdotal information gathered from staff interviews.

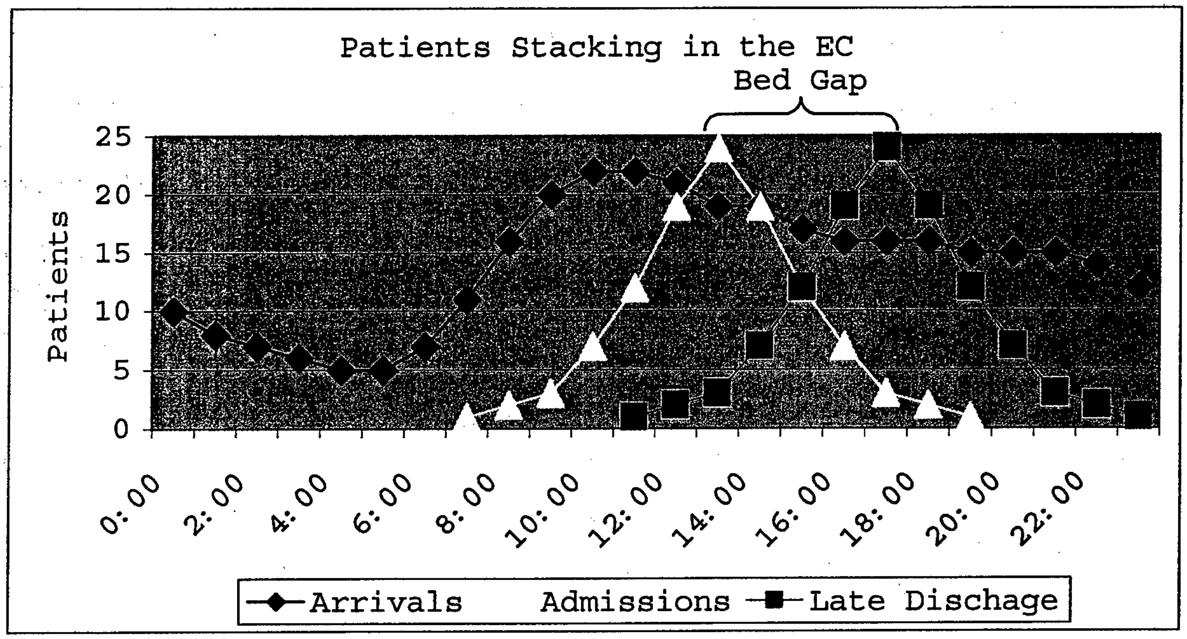

Figure 2. Average arrivals per hour CY02 with hypothetical normally distributed admissions beginning four hours from arrival allowing for Emergency Center work-up and evaluation. Late discharges beginning at 11:00 result in 4-hour bed gap and potential EC saturation.

Figure 3 depicts a shift in the timing of physician rounds that allows earlier discharges. Patients are beginning to arrive in the EC at 7 AM and peak by 11 AM. Assuming the clinical evaluation and decision to admit occurs within three hours, the demand for beds will be between 10 AM and 2 PM. If discharges can be accomplished prior to the demand for admissions, the bed gap and EC wait time is minimal.

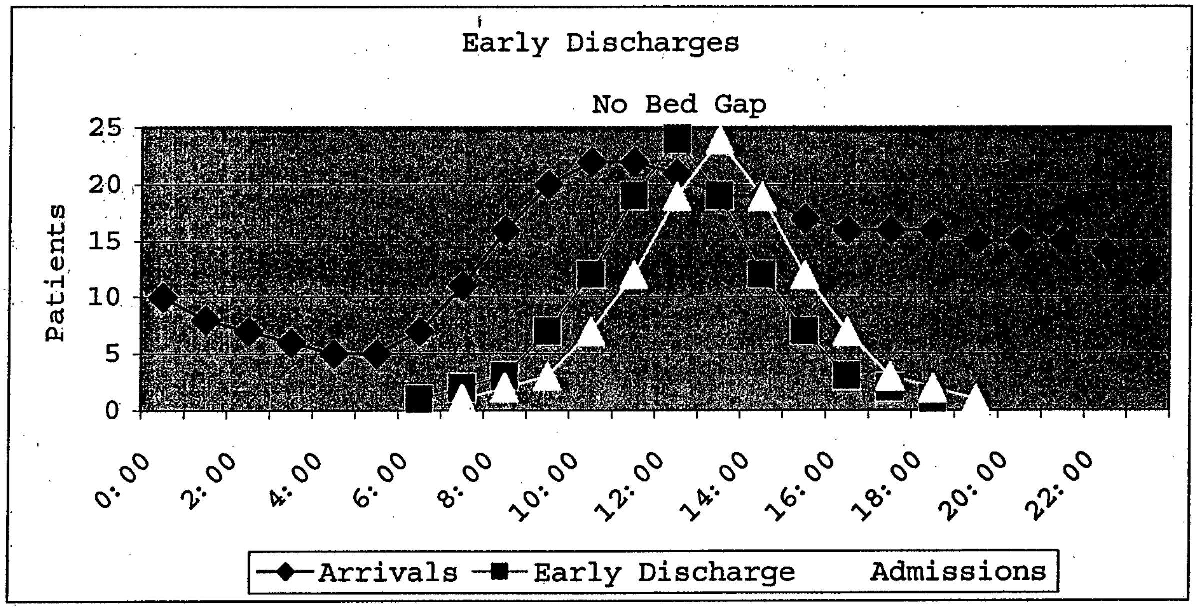

Figure 3. Average arrivals per hour CY02 with hypothetical normally distributed admissions beginning four hours from arrival allowing for Emergency Center work-up and evaluation. Evening mini-rounds enable early discharge and theoretically open up beds prior to admissions demand.

A simple analysis of rounding times, admission times, and discharge times was conducted to demonstrate the potential increase bed availability and ease EC diversions. Unfortunately, patient throughput measured in days will be minimally affected by changes in rounding times. However, EC diversions and wait time should be reduced.

The gap between admission and discharge can be construed as wait-time in the EC, the source of 80% of Ben Taub Hospital's admissions. A change in rounding times that shifts the inpatient discharge times will allow earlier emergency center discharge to inpatient status, reduce wait-time, and potentially reduce the number of diversions. However, arbitrarily changing the discharge time by 4-hours had no effect on the relationship.

Therefore, a second approach of changing the rounding times to 7:00 AM or earlier and changing the discharge times accordingly was attempted. The relationship also failed to yield any significance.

If the physician rounds are occurring at 7:25 AM, why does it take 9 hours to discharge? A confounding variable, such as the out-of-sight factor, must be present and warrants further investigation. The out-of-sight factor does not necessarily explain the 9-hour discharge process. Certainly, the discharge process involves administrative and clinical steps and is different for each patient. Unfortunately, patient level detailed data were unavailable at the time of this study therefore average times were analyzed as the best available measure.

Anecdotally, interviews with the nursing staff indicate that physicians make their rounds early in the morning, go to meetings and conferences, and write the discharge orders about 4 hours later. Improvements in patient flow can be made with a simple paradigm shift that values early discharges. In addition, nighttime planning rounds could eliminate morning delays in waiting for test results and could facilitate physician decision-making to speed the discharge process.

Physicians could also speed the delivery care. Statistical differences exist among lengths of stay for specific DRGs based on the location or unit performing care (Table 14). Statistical differences also exist among lengths of stay by DRG based on patient demographics such as race and age at discharge. Demographics need to be considered as they do have an affect on the models. However, patient demographics are largely uncontrollable. Therefore, the focus of the following discussion will be the location or unit performing the patient care and the affect on length of stay by DRG.

The coefficient associated with each variable for the 36 models displayed in Table 14 adds or subtracts from length of stay depending upon the relationship. The magnitude of the association is reflected in the absolute value of the coefficient. The higher the coefficients value the greater the effect on length of stay. Heart failure and shock (DRG 127) is a good example. The length of stay for excluded variables of males, African-Americans, and stays on Unit 6D are reflected in the constant (4.166). Interpretations of the coefficients have two components: direction and magnitude. For example, females have lower lengths of stay than males but the magnitude is low at .154 days. Heart failure and shock patients who are cared for on unit 6E (MICU) tend to stay in the hospital more than 5 times as much as those treated on the reference Unit 6D (telemetry).

Treating a patient in a specialized unit does not mean that length of stay will always be reduced. The heart failure and shock discussion above shows that patients treated in the Medical Intensive Care Unit stay longer than patients who are merely monitored on a telemetry unit. DRG 28, traumatic stupor and coma less than one hour for age 18 and above with complications, also demonstrates this point. Lengths of stay on Unit 4E, Surgical Intensive Care, are 4.4 days longer than those of the reference unit (4A), a surgical ward.

The specialized unit and the displaced patient theories seem evident for many DRGs. Patient's who are older than 17 years of age and diagnosed with seizure and headache with complications (DRG 24) stayed 32 extra days if cared for on a regular medicine unit (5D) compared to a medicine unit specializing in Neurology (5C). DRG 89, simple pneumonia, when treated on a medicine ward (6B) has an 8.6 day shorter length of stay than when displaced to the Orthopedic Unit (5B) and 11.9 days shorter than a surgical ward (4B). DRG 114, upper limb and toe amputation, shows a 29.1-day increase in length of stay for patients cared for on medicine ward (5D) versus a surgical ward (4A). For DRG 148, major bowel procedures, patients who recover on a surgical ward (4B) stay 33.4 days less than those who recover on a medicine ward (5D). DRGs 157, 223, 253, 320, 415, 442, 478, and 483 continue this trend and suggest that length of stay is reduced when patients are treated on wards more appropriate to their care.

The general theme of the DRG length of stay study seems to show that displaced patients have longer lengths of stay. However, not all lengths of stay difference are necessarily inappropriate. Differences indicate a potential for increase patient throughput and should be closely examined by a multidisciplinary clinical team to determine if standard clinical processes could reduce length of stay.

Conclusion

The results suggest areas of opportunity to reduce length of stay and increase patient throughput. Table 15 shows the potential virtual bed gain from scenarios of incremental reductions in length of stay. Elimination of just one inpatient day is equivalent to having an extra 100 beds. Stated another way, reducing the length of stay for each patient allows more patients to be seen each year thus increasing throughput.

Table 15. *Length of Stay Reduction Scenarios*

Scenario	Length of Stay	Patients per Year	Equivalent Beds	Virtual Bed Gain
Current	5.87 Days	36,562	588	-
Reduction				
Minimal	5.27 Days	40,725	648	60
Pragmatic	4.87 Days	44,070	688	100
Dramatic	4.37 Days	49,112	738	150

Table 16 summarizes the potential increase in patient throughput. All calculations divide the number of extra patient care days by the current 5.87-day length of stay. Eliminating inappropriate admissions with a dedicated observation unit could result in 56 more patients being seen each year. Seven of those 56 patients would be available simply by eliminating the excess stay above 23-hours. Accelerated post-acute transfers could result in almost 352 additional patients being seen in the six-month period, if the medically stable portion of their stay were eliminated. Changing physician rounding times would result in reduced EC waiting times but would not increase patient throughput. Shortening the length of care could result in 10,761 more patients receiving care.

Table 16. *Potential Increased Throughput Summary*

Strategy	Potential Increased Throughput
Appropriate Admissions	56
Accelerated Post-Acute Transfers	704
Earlier Patient Discharges	0
Expedited Care Delivery	10,761

Note: Calculations based on 5.87 days average length of stay; accelerated transfers extrapolated to 12 months; expedited care: 21% of cases accounted for 63,167.23 days over 6 six days of stay. Results cannot be totaled due to system interactions

The potential additional patient throughput cannot be totaled because of interactions with the patient care processes. For example, eliminating the long stay patient will reduce the average length of stay and affect the calculations for expedited care. An observation unit would free up inpatient beds; however, the relatively short stays would be replaced with regular inpatient stay of 5.87 days and would increase the average length of stay.

Recommendations

Ben Taub should consider the costs and benefits of building a 10-bed observation unit. Assuming normally and independently distributed data, the inappropriate admission analysis revealed that the average number of observation patients per day is 1.7 patients with a standard deviation of 1.00. Almost all cases fall within 3 standard deviations from the average. Therefore, an observation unit sized for 4.7 patients captures 99.9% of the probability of occurrence. In other words, Ben Taub will most likely not see more than 5 patients per day that require observation to determine the need for admission. However, the historical maximum is 9 patients per day. Therefore, the recommended observation unit size is 10-beds.

Focused training on the proper use of observation patient classification, particularly for Obstetrics and Pediatrics (Units 3A, 3B, 3C, 5E, and 5G), should be beneficial. Further, the possible summertime trend for excessive observation use could be a function of newly assigned medical residents. Academic Attending Physicians should be especially vigilant during the resident turnover and initial training period.

A multidisciplinary team should develop admission and continued stay criteria. An automated bed placement system would provide the ability to monitor admissions and pinpoint discharge delays. Monitoring the admissions would catch inappropriate admissions motivated by lack of access to outpatient tests such as CT-scans. Further, the out-of-sight phenomena could be quantified and monitored.

Aggressive discharge planning by social workers beginning the first day of admission will be enormously beneficial. A proactive discharge coordinator for each ward or designated areas would interject discharge planning into the everyday proceedings. Nurses must be encouraged and motivated to take responsibility for discharging patients as quickly as possible. Waiting until the end of the shift to transfer or discharge a patient to avoid getting the next patients must be forbidden. If some nurses are delaying discharges and not willing to adapt to the new rapid discharge philosophy, a mechanism like Code Purple should be considered. Finally, doctors should also be proactive and change their rounding processes.

Better sequencing of the rounding could help (Dawson & Runk, 2000). Rounding in the ICU before the wards delays possible transfers. Wards should be done first and discharge orders should be written immediately. Discharge holding should be fully utilized. Then, the ICU will have outlets to step down patients and free up critical care beds for those patients waiting in the EC. Meetings and conferences should be scheduled in the afternoon allowing discharges and transfers to occur as early as possible. Nighttime planning rounds should be implemented in order to arrange for the appropriate tests. The test results will be available to speed up the morning rounds and discharges.

Expediting care is possible with peer review and clinical practice guidelines. The variability in length of stay suggests reduced stay is possible. However, the lack of acuity information makes it very difficult to draw complete conclusions. Other process improvements should be implemented before attempting to expedite care.

References

The Advisory Board. (2003). Maximizing hospital capacity: Expediting patient throughput can provide an immediate solution to capacity shortages. *Healthcare Executive, 18*(1), 58-59.

Anonymous. (1999). Time studies identify interventions to boost patient flow in your ED. *Ed Management. 11*(12), 133-137.

Anonymous. (2000). Code purple mode relieves ED bottlenecks. *Ed Management. 12*(12), 139-142.

Anonymous. (2002). Reports say diversion on the rise: Use technology to overhaul patient flow. *Ed Management. 14*(3), 25-27.

Anonymous. (2003a). Use protocol to send inpatient holds upstairs. *Ed Management. 15*(4), 43-44.

Anonymous. (2003b). Critical-care transport team improves care. *Ed Management. 15*(1), 6-7.

Backer, L. A., (2002). Strategies for better patient flow and cycle time. *Family Practice Management. 9*(6), 45-50.

Bennett, P.J., Fosbinder, D., & Williams, M. (1997). Care coordination in an academic medical center. *Nursing Case Management. 2*(2), 75-82.

Bristow, D.P., & Herrick, C.A. (2002). Emergency department case management: The dyad team of nurse case manager and social worker improve discharge planning and patient and staff satisfaction while decreasing inappropriate admissions and costs: A literature review. *Lippincott's Case Management.* 7(3), 121-128.

Chan L., Reilly, K.M., & Salluzzo, R.F. (1997). Variables that affect patient throughput times in an academic emergency department. *American Journal of Medical Quality. 12*(4), 183-186.

Chan, L., & Kass, L.E. (1999). Impact of medical student preceptorship on ED patient throughput time. *American Journal of Emergency Medicine. 17*(1), 41-43.

Czaplinski, C., & Diers, D. (1998). The effect of staff nursing on length of stay and mortality. *Medical Care, 36*(12), 1626-1638.

The Daily Brief. (2001). Memorial Hermann: New fast-track ED cutting wait times. *The Advisory Board.* Retrieved October 1, 2003, from http://www.advisory.com/members/basecontent.asp?contentid=24316&collectionid=4&program=1

Dawson, S., & Runk, J. A. (2000). Right patient? Right bed? A question of appropriateness. *AACN Clinical Issues: Advanced Practice in Acute & Critical Care, 11*(3), 375-385.

De Hartog, J. (1964). *The Hospital*. New York, Atheneum

ED overcrowding. (2003, August 4). *Inside the Joint Commission.* 6-7.

Eddy, D. (1990). Clinical decision making from theory to practice: the challenge. *Journal of the American Medical Association, 263*(2), 287-290.

Harris County Hospital District. (n.d.a,) *History*. Retrieved October 1, 2003 from http://www.hchdonline.com/about/history.htm

Harris County Hospital District. (n.d.b.) *Ben Taub General Hospital*. Retrieved October 1, 2003 from http://www.hchdonline.com/about/facilities/bentaubgh.htm

Harris County Hospital District. (2003). [Annual report, patient services summary]. Unpublished raw data.

The Healthcare Advisory Board (2002). *Maximizing hospital capacity: Expediting throughput in an era of shortage*. Washington D.C.: The Advisory Board Company.

The Healthcare Advisory Board (2002). *Throughput gap analysis: Member toolkit for diagnosing performance improvement opportunities*. Washington D.C.: The Advisory Board Company.

Johnstone, P., & Zolese, G. (1999). Systematic review of the effectiveness of planned short hospital stays for mental health care. *British Medical Journal. 318*(7195), 1387-1390.

Karpiel M. S. (2000). Benchmarking facilitates process improvement in the emergency department. *Healthcare Financial Management. 54*(5), 54-59.

Knight, D. (2003, October 9). Hospital turning ER care on its ear. *Indianapolis Star*. Retrieved October 10, 2003, from http://www.indystar.com/print/articles/2/081663-8372-031.html

Kwan, J., & Sandercock, P. (2003). In-hospital care pathways for stroke: A Cochrane systematic review. *Stroke. 34*(2), 587-588.

Kyriacou, D. N., Ricketts, V., Dyne, P. L., McCollough, M. D., & Talan, D. A. (1999). A 5-year time study analysis of emergency department patient care efficiency. *Annals of Emergency Medicine*. *34*(3), 326-335.

Lee, A. H, Fung, W. K., & Fu, B. (2003). Analyzing hospital length of stay: Mean or median regression? *Medical Care* *41*(5), 681-686.

Lenox, A. C., & New, H. (1997). Clinical observation units help manage costs and care. *Healthcare Financial Management*. *51*(4), 88-89.

London, J.A., & Battistella, F.D. (2003). Is there a relationship between trauma center volume and mortality? *Journal of Trauma-Injury Infection & Critical Care*. *54*(1), 16-24.

Margulies, D.R., Cryer, H.G., McArthur, D.L., Lee, S.S., Bongard, F.S., & Fleming, A.W. (2001). Patient volume per surgeon does not predict survival in adult level I trauma centers. *Journal of Trauma-Injury Infection & Critical Care*. *50*(4), 597-601.

McGlory, G., Burney, M., Hargrave, J., Luna, S., Smith, I., & Wakhu, D. (2002). Does caring for displaced specialty unit patients affect the critical care nurse's perceptions of ability and job satisfaction? *International Journal of Trauma Nursing*. *8*(3), 76-80.

Miro, O., Sanchez, M., Espinosa, G., Coll-Vinent, B., Bragulat, E., & Milla, J. (2003). Analysis of patient flow in the emergency department and the effect of an extensive reorganisation. *Emergency Medicine Journal. 20*(2):143-148.

Nathens, A.B., Jurkovich, G.J., Maier, R.V., Grossman, D.C., MacKenzie, E.J., Moore, M., & Rivara, F.P. (2001). Relationship between trauma center volume and outcomes. *Journal of the American Medical Association. 285*(9), 1164-1171.

National Center for Health Statistics. (2002). *National hospital ambulatory medical care survey; 2000 emergency department summary*. Retrieved October 3, 2003, from http://www.cdc.gov/nchs/data/ad/ad326.pdf

Nursing Executive Watch. (2003a). Gaston Memorial Hospital: Institution wide overhaul of processes improves ED throughput. *The Advisory Board*. Retrieved August 19, 2003, from http://www.advisory.com/members/basecontent.asp?contentid=33075&collectionid=30&program=4

Nursing Executive Watch. (2003b). '30-30' ED program improves patient throughput, satisfaction scores. *The Advisory Board*. Retrieved August 19, 2003, from http://www.advisory.com/members/basecontent.asp?contentid=33838&collectionid=30&program=4

Proudlove, N. C., Gordon, K., & Boaden, R. (2003). Can good bed management solve the overcrowding in accident and emergency departments? *Emergency Medicine Journal, 20*(2), 149-155.

Renholm, M., Leino-Kilpi, H., & Suominen, T. (2002) Critical pathways. A systematic review. *Journal of Nursing Administration*. *32*(4), 196-202.

Schlegel, D. (2003, September 30). One out of four Texans lack health insurance. *Houston Chronicle*. Retrieved October 1, 2003, from http://www.chron.com/cs/CDA/ssistory.mpl/business/2127837

Smith, R. C. (2002). Discharge planning. *Nursing Standard*. *17*(5), 33-37.

U.S. Census Bureau. (2002). 2002 American Community Survey Profile. Retrieved October 1, 2003 from http://www.census.gov/acs/www/Products/Profiles/Single/2002/ACS/TX.htm

U.S. Census Bureau. (2003, September 30). *Numbers of Americans with and without health insurance rise, Census Bureau reports*. Retrieved October 1, 2003, from http://www.census.gov//Press-Release/www/003/cb03-154.html

Wennberg, J., & Gittelsohn, A. (1973). Small area variations in health care delivery. *Science, 182,* 1102-1108.